CLAIMS

WE CLAIM:

1. A method of determining the location of a fault on a signal and/or electrical energy transmission line, comprising the steps of:

a) providing an electrical signal and/or energy transmission line and functionally implementing at least first and second transmitter/receiver means for producing and receiving bursts of high frequency signal thereupon, said first and second transmitter/receiver means being separated from one another by a known spatial distance along said electrical signal and/or energy transmission line;

b) providing a means for storing high frequency signal data transmitted and received by each of said first and second transmitter/receiver means, as a function of time;

said method further comprising repeating step c until an unexpected burst of high frequency signal not transmitted by either of said first and second transmitter/receiver means, is received by both said first and second transmitter/receiver means, said step c being:

c) while storing high frequency signal data which documents the transmission and receipt of high frequency signals sent and received by both said first and second transmitt r/receiver means:

upon receipt of a re- ccuring initiating event detected by said first transmitter/receiver means causing said first transmitter/receiver means to generate and transmit a burst of high frequency signal which propagates toward said second transmitter/receiver means, said burst of high frequency signal being received by said second transmitter/receiver means; and

at least one selection from the group consisting of:

upon receipt of said re-occuring initiating event detected by said second transmitter/receiver means, causing said second transmitter/receiver means to generate and transmit a burst of high frequency signal which propagates toward said first transmitter/receiver means, said burst of high frequency signal being by said first transmitter/receiver means; and

after detection of a signal from the first transmitter/receiver means, causing said second transmitter/receiver means to generate and transmit a burst of high frequency signal which propagates toward said first transmitter/receiver means, said burst of high frequency signal being received by said first transmitter/receiver means;

d) said method further comprising, upon the detection and storage of an unexpected burst of high frequency signal by, not generated by either said first or second transmitter/receiver means, causing at l ast transmitted and rec ived high frequency signal

data generated in step c which corresponds to the last occurance of the re-occuring initiating event, and data which documents the unexpected high frequency signal to be fixed in said means for storing high frequency data as functions of time;

e) by utilizing data stored in said means for storing high frequency signal data, developing and aligning first and second effective high frequency data plots vs time which correspond to signals received by said first and second transmitter/receiver means respectively, so that:

a difference in time between the initiation of the burst of high frequency signal provided by the first transmitter/receiver means in said first effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said second transmitter/receiver means in said second effective high frequency data plot vs time;

is caused to be equal to:

a difference in time between the initiation of the burst of high frequency signal provided by the second transmitter/receiver means in said second effective high frequency data plot vs time and receipt of said burst of high frequency signal by said first transmitter/receiver means in said first effective high frequency data plot vs time;

said effective data plots including data corresponding to detection of said unexpected burst of high frequency signal not generated by either said first or second transmitter/receiver means;

f) measuring a resulting time difference in said first and second aligned effective plots vs. time between corresponding analogous points in unexpected high frequency signal detected by said first transmitter/receiver means and said second transmitter/receiver means; and

g) converting said time difference determined in step f, into a spatial distance of location of said signal and/or electrical energy transmission fault located between said first and second transmitter/receiver means.

2. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which the signal and/or electrical energy transmission line is a 50 or 60 Hz AC electrical power transmission line and in which said re-occuring initiating event which is utilized to cause said first transmitter/receiver means to generate and transmit a burst of high frequency signal is a voltage and/or current zero crossing which arrives at said first and second transmitter/receiver means at times offset from one another by the time of propagation of said zero crossing between said first and second transmitter/receiver means based on the velocity of propagation thereof along said 50 or 60 Hz AC electrical power transmission line.

3. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 2, in which the initiating signal voltage and/or current zero crossing is utilized to cause said second transmitt r/receiver means to g nerate and

transmit a burst of high frequ ncy signal and wherein said signal voltage and/or current zer cr ssing propagates from said first to second transmitter/ receiver at a slower velocity of propagation than does the burst of high frequency signal transmitted from said first transmitter/receiver means and received by said second transmitted/received means or from said second transmitted/received means to first transmitted/ received means.

4. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which the initiating signal received by the second transmitter/receiver is generated by the first transmitter/receiver.

5. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which there is no time difference in said aligned effective plots vs. time, between analogous points in the detection of the unexpected high frequency signal or fault by said first transmitter/receiver means and said second transmitter/receiver means, and the fault on said signal and/or electrical energy transmission line is located substantially half way between said first and second transmitter/receiver means.

6. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which there is a time difference in said aligned effective plots vs. time, between analogous points in the detection of the unexpected high frequ ncy signal or fault by said first

transmitt r/r ceiver m ans and said second transmitter/receiver means, and the fault on said signal and/or electrical energy transmission line is located at a selection from the group consisting of:

being closer to said first transmitter/receiver means; and

being closer to said second transmitter/receiver means.

7. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which the terminology high frequency includes frequencies above 1,000 Hz.

8. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which the frequency content of the high frequency bursts transmitted by said first and second transmitter/receiver means is selected to approximate the frequency content of said unexpected high frequency signal resulting from a fault on the electrical signal and/or energy transmission line so as to provide substantially similar velocity of propagation.

9. A method for determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 7, in which the frequency of the unexpected high frequency signal is on the order of 1 MHz and that of the high frequency bursts transmitted by said first and second transmitted/received means is on the ord r of 300-500 KHz

10. A method of determining the l cation of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which there are more than two transmitter/receiver means.

11. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which said means for storing high frequency signal data transmitted and received by each of said first and second transmitter/receiver means, as a function of time is configured in such a manner to allow storing data corresponding to multiple fault events.

12. A method of determining the location of a fault on a signal and/or electrical energy transmission line as in Claim 1, in which the electrical signal and/or energy transmission line comprises at least two conductors.

13. A method of determining a location of a fault on a signal and/or electrical energy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is a three-phase power transmission system.

14. A method of determining a location of a fault on a signal and/or electrical energy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is a power transmission system using an AC power wave that is low enough in frequency such that its velocity of propagation is slow enough so as to allow the markers to propagate fast r than the AC power wave does.

15. A method of d termining a location of a fault on a signal and/or electrical en rgy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is such that the invention transmitter/receivers can randomly trigger each other so as to exchange marker signals. The randomly timed triggering events are of sufficient low frequency so that the marker signals have time to traverse reasonable lengths of cable under test, as required by the application and not be mixed with each others markers.

16. A method of determining a location of a fault on a signal and/or electrical energy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is a single-phase power transmission system.

17. A method of determining a location of a fault on a signal and/or electrical energy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is an aircraft power transmission system.

18. A method of determining a location of a fault on a signal and/or electrical energy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is a spacecraft power transmission system.

19. A method of determining a location of a fault on a signal and/or electrical energy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is a commercial or naval ship pow r transmission system.

20. A method of determining a location of a fault on a signal and/or electrical energy transmission line as in Claim 9, in which the signal and/or electrical energy transmission line is a localized industrial power transmission system.

21. A method of determining the location of a fault on a signal and/or electrical energy transmission line, comprising the steps of:

a) providing an electrical signal and/or energy transmission line and functionally implementing thereupon first and second transmitter/receiver means for producing and optionally receiving bursts of high frequency signal, and a receiver means for receiving bursts of high frequency signal, said first and second transmitter/receiver means each being separated from said receiver means which is present therebetween by a known spatial distance along said electrical signal and/or energy transmission line;

b) providing a means for storing high frequency signal data transmitted and received by each of said first and second transmitter/receiver means, as a function of time;

said method further comprising repeating step c until an unexpected burst of high frequency signal not transmitted by either of said first and second transmitter/receiver means, is received by both said first and second transmitter/receiver means and said receive means, said step c being:

c) while storing high frequency signal data

which documents the transmission and receipt of high frequency signals sent by both said first and second transmitter/receiver means and received by said receiver means:

causing said first transmitter means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

causing said second transmitter means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

d) said method further comprising, upon the detection of an unexpected burst of high frequency signal by said first or second transmitter/receiver means and/or receiver means, but not generated by either said first or second transmitter/receiver means, causing at least transmitted and received high frequency signal data generated in step c which corresponds to the last occurance of the re-occuring initiating event, and data which documents the unexpected high frequency signal to be fixed in said means for storing high frequency data as functions of time;

e) by utilizing data stored in said means for storing high frequency signal data, developing and aligning first and second effective high frequency data plots vs time which correspond to signals received by said first and second transmitter/receiver means to receiver means respectively, so that:

a difference in time between the initiation of the burst of high frequ ncy signal provided by the

first transmitter/r ceiver means in said first effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said receiver means in said second effective high frequency data plot vs time;

is caused to be equal to:

a difference in time between the initiation of the burst of high frequency signal provided by the second transmitter/receiver means in said second effective high frequency data plot vs time and receipt of said burst of high frequency signal by said receiver means in said first effective high frequency data plot vs time;

said effective data plots including data corresponding to detection of said unexpected burst of high frequency signal not generated by either said first or second transmitter/receiver means;

f) measuring a resulting time difference in said first and second aligned effective plots vs. time between corresponding analogous points in unexpected high frequency signal detected by said receiver means; and

g) converting said time difference determined in steps f into a spatial distance of location of said unexpected high frequency signal between said first and second transmitter/receiver means.

22. A method as in Claim 21 in which the step c causing of said first transmitter means to g nerate

and transmit a burst of high frequency signal is based upon:

receipt thereby of a re-occuring initiating event; and

in which the step c causing of said second transmitter means to generate and transmit a burst of high frequency signal is based upon a selection from the group consisting of:

receipt thereby of a re-occuring initiating event; and

a signal from the first transmitter/receiver means; by said receiver means.

23. A method of determining the location of a fault on a signal and/or electrical energy transmission line, comprising the steps of:

a) providing an electrical signal and/or energy transmission line and functionally implementing at least first and second transmitter means for producing bursts of high frequency signal thereupon and a receiver means for receiving bursts of high frequency signal, said first and second transmitter means being separated from one another by a known spatial distance along said electrical signal or energy transmission line, and said separate receiver means being placed midway therebetween;

b) providing a means for storing high frequency signal data transmitted by each of said first and

s cond transmitter means and received by said rec iver means, as a function of tim ;

said method further comprising repeating step c until an unexpected burst of high frequency signal not transmitted by either of said first and second transmitter means, is received by receiver means, said step c being:

c) while storing high frequency signal data which documents the transmission of high frequency signals sent by both said first and second transmitter means and receipt thereof by said receiver means, in any functional order:

causing said first transmitter means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

causing said second transmitter means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

d) said method further comprising, upon the detection of an unexpected burst of high frequency signal by said receiver means, causing said unexpected burst of high frequency signal and high frequency signal data generated in step c which corresponds to at least the last occurance of the first and second transmitter generated bursts of high frequency signal, to be fixed in said means for storing high frequency data as functions of time;

e) by utilizing data stored in said means for storing high frequency signal data as a function of

time received by said receiver means from said first and second transmitters respectively, developing and aligning first and second effective high frequency data plots vs time so that:

a difference in time between the initiation of the burst of high frequency signal provided by the first transmitter means in said first effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said receiver means in said second effective high frequency data plot vs time;

is caused to be equal to:

a difference in time between the initiation of the burst of high frequency signal provided by the second transmitter means in said second effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said receiver means in said first effective high frequency data plot vs time;

said effective data plots including data corresponding to the detection of said unexpected burst of high frequency signal not generated by either said first or second transmitter means;

f) measuring a resulting time difference in said first and second aligned effective plots vs. time between corresponding analogous points in unexpected high frequency signal detected by said receiver means; and

g) converting said time differenc determined in step f into a spatial distance of location of said unexpected burst of high frequ ncy signal between said first and second transmitter means.

24. A method as in Claim 23 in which the step c causing of said first transmitter means to generate and transmit a burst of high frequency signal is based upon:

receipt thereby of a re-occuring initiating event; and

in which the step c causing of said second transmitter means to generate and transmit a burst of high frequency signal is based upon a selection from the group consisting of:

receipt thereby of a re-occuring initiating event; and

a signal from the first transmitter/receiver means; by said receiver means.

25. A method of determining the location of a fault on a signal and/or electrical energy transmission line, comprising the steps of:

a) providing an electrical signal and/or energy transmission line and functionally implementing at least first and second transmitter/receiver means for producing and receiving bursts of high frequency signal thereupon, said first and second transmitter/receiver means being separated from one anoth r by a known spatial distance along said electrical signal and/or energy transmission line;

b) providing a means for storing high frequency signal data transmitted and received by each of said first and second transmitter/receiver means, as a function of time;

said method further comprising repeating step c until an unexpected burst of high frequency signal not transmitted by either of said first and second transmitter/receiver means, is received by both said first and second transmitter/receiver means, said step c being:

c) while storing high frequency signal data which documents the transmission and receipt of high frequency signals sent and received by both said first and second transmitter/receiver means, in any functional order:

causing said first transmitter/receiver means to generate and transmit a burst of high frequency signal which propagates toward said second transmitter/receiver means, said burst of high frequency signal being received by said second transmitter/receiver means; and

causing said second transmitter/receiver means to generate and transmit a burst of high frequency signal which propagates toward said first transmitter/receiver means, said burst of high frequency signal being received by said first transmitter/receiver means; and

d) said method further comprising, upon th detection of an unexpect d burst of high frequency signal by, not generated by either said first or second transmitter/receiver means, causing at least transmitted and received high frequency signal data generated in step c which corresponds to the last occurance of the transmission by each of said first and second transmitter/receiver means, and data which documents the unexpected high frequency signal to be fixed in said means for storing high frequency data as functions of time;

e) by utilizing data stored in said means for storing high frequency signal data as functions of time, developing and aligning first and second effective high frequency data plots vs time which correspond to signals received by said said first and second transmitter/receiver means respectively, so that:

a difference in time between the initiation of the burst of high frequency signal provided by the first transmitter/receiver means in said first effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said second transmitter/receiver means in said second effective high frequency data plot vs time;

is caused to be equal to:

a difference in time between the initiation of the burst of high frequency signal provided by the second transmitter/receiver means in said second effective high frequency data plot vs time and r ceipt of said burst of high frequency signal by

said first transmitt r/receiver means in said first effective high frequency data plot vs time;

said effective data plots including data corresponding to detection of said unexpected burst of high frequency signal not generated by either said first or second transmitter/receiver means;

f) measuring a resulting time difference in said first and second aligned effective plots vs. time between corresponding analogous points in unexpected high frequency signal detected by said first transmitter/receiver means and said second transmitter/receiver means; and

g) converting said time difference in time determined in step f into a spatial distance of location of the source of the unexpected high frequency signal located between said first and second transmitter/receiver means.

26. A method as in Claim 25 in which the step c causing of said first transmitter/receiver means to generate and transmit a burst of high frequency signal is based upon:

receipt thereby of a re-occuring initiating event; and

in which the step c causing of said second transmitter/receiver means to generate and transmit a burst of high frequency signal is based upon a selection from the group consisting of:

rec ipt thereby of a r -occuring initiating event; and

a signal from the first transmitter/receiver means by said receiver means.

27. A method of determining the velocity of propagation of high frequency signals on a signal and/or electrical energy transmission line, comprising the steps of:

a) providing an electrical signal and/or energy transmission line and functionally implementing at least first and second transmitter/receiver means for producing bursts of high frequency signal thereupon and a receiver means for receiving bursts of high frequency signal, said first and second transmitter/receiver means being separated from one another by a known spatial distance along said electrical signal or energy transmission line, and said separate receiver means being placed midway therebetween;

b) providing a means for storing high frequency signal data transmitted by each of said first and second transmitter/receiver means and received by said receiver means, as a function of time;

said method further comprising repeating step c until an unexpected burst of high frequency signal not transmitted by either of said first and second transmitter/receiver means, is received by receiver means, said step c being:

c) while storing high frequency signal data

which documents the transmission of high frequency signals sent by b th said first and second transmitter/receiver means and receipt thereof by said receiver means, in any functional order:

causing said first transmitter/receiver means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

causing said second transmitter/receiver means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

d) by utilizing data stored in said means for storing high frequency signal data as a function of time received by said receiver means from said first and second transmitter/receivers respectively, developing and aligning first and second effective high frequency data plots vs time so that:

a difference in time between the initiation of the burst of high frequency signal provided by the first transmitter/receiver means in said first effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said receiver means in said second effective high frequency data plot vs time;

is caused to be equal to:

a difference in time between the initiation of the burst of high frequency signal provided by the second transmitter/receiver means in said s cond

effectiv high frequency data plot vs time, and the receipt of said burst of high frequency signal by said receiver means in said first effective high frequency data plot vs time;

dividing the known spatial separation of the first and second transmitter/receiver means by the time difference determined in step d.

28. A method of determining the velocity of propagation of high frequency signals on a signal and/or electrical energy transmission line, comprising the steps of:

a) providing an electrical signal and/or energy transmission line and functionally implementing at least first and second transmitter means for producing bursts of high frequency signal thereupon and a receiver means for receiving bursts of high frequency signal, said first and second transmitter means being separated from one another by a known spatial distance along said electrical signal or energy transmission line, and said separate receiver means being placed midway therebetween;

b) providing a means for storing high frequency signal data transmitted by each of said first and second transmitter means and received by said receiver means, as a function of time;

c) while storing high frequency signal data which documents the transmission of high frequency signals sent by both said first and second transmitter means and receipt ther of by said receiver means, in

any functional order:

causing said first transmitter means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

causing said second transmitter means to generate and transmit a burst of high frequency signal which propagates toward said receiver means; and

d) by utilizing data stored in said means for storing high frequency signal data as a function of time received by said receiver means from said first and second transmitters respectively, developing and aligning first and second effective high frequency data plots vs time so that:

a difference in time between the initiation of the burst of high frequency signal provided by the first transmitter means in said first effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said receiver means in said second effective high frequency data plot vs time;

is caused to be equal to:

a difference in time between the initiation of the burst of high frequency signal provided by the second transmitter means in said second effective high frequency data plot vs time, and the receipt of said burst of high frequency signal by said receiver means in said first effective high frequency data plot vs time;

dividing the known spatial separation of th first and second transmitter means to the receive means by the time difference determined in step d.